INSTRUCTION:

This section consists of **FOUR (4)** structured questions. Answer **ALL** questions.

ARAHAN:

*Bahagian ini mengandungi **EMPAT (4)** soalan struktur. Jawab semua soalan.*

QUESTION 1

SOALAN 1

CLO1

(a) State **THREE (3)** reactions that can use batch reactor.

*Senaraikan **TIGA (3)** tindak balas yang boleh menggunakan reaktor kelompok.*

[3 marks]

[3 *markah*]

CLO1

(b) Batch reactors are occasionally used for highly endothermic or exothermic reactions.

Reaktor sekelompok kadangkala digunakan untuk tindak balas yang sangat endotermik atau eksotermik.

i) Explain heat transfer in batch reactor operation**.**

Terangkan pemindahan haba dalam pengoperasian reaktor sekelompok.

[4 marks]

[*4 markah*]

ii) Elaborate **TWO (2)** disadvantages of batch reactor.

*Huraikan **DUA (2)** kelemahan reaktor sekelompok.*

[4 marks]

[*4 markah*]

CLO1

(c) The rate of a reaction is usually expressed as the change in concentration of reactants or products per unit time. For instance, in the Contact Process, which involves the reaction between sulphur dioxide gas and oxygen gas to form sulphur trioxide (SO_3), the rate can be measured by monitoring the concentration changes of these substances per unit time.

Kadar tindak balas biasanya dinyatakan sebagai perubahan kepekatan bahan tindak balas atau produk per unit masa. Sebagai contoh, dalam Proses Sentuhan, yang melibatkan tindak balas antara gas sulfur dioksida dan gas oksigen untuk membentuk sulfur trioksida (SO_3), kadar boleh diukur dengan memantau perubahan kepekatan bahan ini setiap unit masa.

i) Write the balanced chemical equation, rate law and overall order of the reaction above.

Tuliskan persamaan kimia seimbang, hukum kadar dan tertib keseluruhan tindak balas yang dinyatakan di atas.

[6 marks]

[*6 markah*]

ii) Calculate the rate of disappearance of oxygen and the rate of formation of sulphur trioxide if the rate of disappearance of sulphur dioxide is 8 mol/dm^3. s.

Kirakan kadar kehilangan oksigen dan pembentukan sulfur trioksida jika kadar kehilangan sulfur dioksida ialah 8 mol/dm^3. s

[8 marks]

[*8 markah*]

QUESTION 2

SOALAN 2

CLO1 (a) Describe the continuous stirred tank reactor (CSTR) process.
*Terangkan proses bagi reaktor tangki teraduk berterusan (*CSTR*).*

[3 marks]
[3 *markah*]

CLO1 (b) A CSTR can be used as an individual unit or a multiple units that is joined together to form a chain of stirred tanks. Discuss:
CSTR boleh digunakan sebagai unit individu atau satu set unit yang boleh disambung untuk membentuk rantaian tangki teraduk. Bincangkan:

i) the conversion and temperature for a CSTR in a parallel configuration.
penukaran dan suhu bagi CSTR susunan selari.

[4 marks]
[*4 markah*]

ii) **TWO (2)** disadvantages of CSTR.
DUA (2) *kelemahan CSTR.*

[4 marks]
[*4 markah*]

CLO2 (c) The reaction rate in a CSTR depends on the temperature, material balance, conversion, and energy balance.
Kadar tindak balas dalam CSTR bergantung pada suhu, keseimbangan bahan, penukaran, dan keseimbangan tenaga.

i) Show the design equation for a CSTR in terms of conversion.
Tunjukkan persamaan reka bentuk untuk CSTR dalam sebutan penukaran.

[6 marks]
[*6 markah*]

ii) A series of two CSTRs are used to convert reactant A into product B with a rate constant of 0.5 mol/L·min. The total inlet flow rate is 5 L/min, and the feed concentration of A is 1.5 mol/L. The first reactor achieves a conversion of 30%, while the second reactor achieves an overall conversion of 70%. Calculate the volumes of each CSTR.

Dua buah CSTR yang disusun sesiri digunakan untuk menukar bahan tindak balas A kepada hasil B dengan pemalar kadar 0.5 mol/L·min. Jumlah kadar aliran masuk ialah 5 L/min, dan kepekatan bahan A ialah 1.5 mol/L. Reaktor pertama mencapai penukaran sebanyak 30%, manakala reaktor kedua mencapai penukaran keseluruhan sebanyak 70%. Kira isipadu setiap CSTR.

[8 marks]

[*8 markah*]

QUESTION 3

SOALAN 3

CLO1 (a) State **THREE (3)** examples of applications for plug flow reactors in the petrochemicals industry.

*Nyatakan **TIGA (3)** contoh kegunaan reaktor aliran palam dalam industri petrokimia.*

[3 marks]

[*3 markah*]

CLO1 (b) Plug Flow Reactor (PFR) is a cylindrical tank that's used to perform chemical reactions in a continuous flow.

Reaktor aliran palam (PFR) adalah tangki silinder yang digunakan untuk melaksanakan tindak balas kimia dalam aliran berterusan.

i) Based on Figure 3 (b), explain the movement of fluid through a PFR.

Berdasarkan Rajah 3 (b), jelaskan pergerakan bendalir melalui PFR.

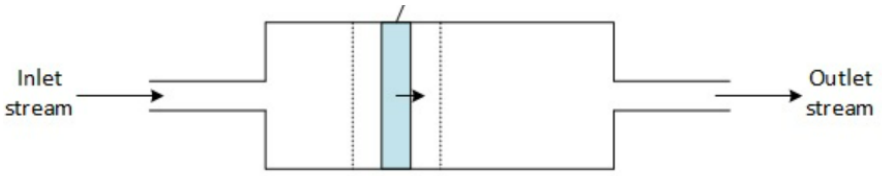

Figure 3 (b) / *Rajah 3 (b)*

[4 marks]

[*4 markah*]

ii) Discuss **FOUR (4)** operation modes of PFR.

*Bincangkan **EMPAT (4)** mod operasi PFR.*

[4 marks]

[*4 markah*]

CLO2 (c) A PFR is a continuous reactor and is also known as a tubular reactor.
PFR ialah reaktor berterusan dan juga dikenali sebagai reaktor tiub.

i) Write the material balance for PFR.
Tuliskan imbangan bahan bagi PFR.

[6 marks]
[*6 markah*]

ii) A gas-phase reaction A → 2B follows first-order kinetics with a rate constant k = 0.1 s^{-1}. The reactor operates at a steady state with an inlet molar flow rate of F_{A0} = 1500 mol/s and an initial concentration C_{A0} = 4 mol/m^3. If 90 % conversion of A is required, calculate the volume of the reactor using the formula below.
Tindak balas fasa gas A → 2B mengikut kinetik tertib pertama dengan pemalar kadar k=0.1 s-1. Reaktor beroperasi pada keadaan mantap dengan kadar aliran molar masuk, F_{A0} = 1500 mol/s dan kepekatan awal C_{A0} = 4 mol/m^3. Jika 90% penukaran A diperlukan, hitung isipadu reaktor dengan menggunakan rumus di bawah.

$$V = F_{A0} \int_0^X \frac{dX}{-r_A} \qquad \int_0^x \frac{dx}{1-x} = \ln \frac{1}{1-x}$$

[8 marks]
[*8 markah*]

QUESTION 4

SOALAN 4

CLO1 (a) List **THREE (3)** applications of homogenous reaction in batch reactor and CSTR in the industry

*Senaraikan **TIGA (3)** kegunaan tindak balas homogen di dalam reaktor sekelompok dan CSTR dalam industri.*

[3 marks]

[*3 markah*]

CLO1 (b) Explain a heterogenous reaction with an example of chemical reactions.

Jelaskan tindak balas heterogen berserta satu contoh tindak balas kimia.

[4 marks]

[*4 markah*]

CLO2 (c) There are homogeneous and heterogenous reactors in which chemical reaction takes place. The reaction occurs either in a single phase or multiphase.

Terdapat reaktor homogen dan heterogen di mana tindak balas kimia berlaku. Tindak balas yang berlaku adalah sama ada dalam fasa tunggal atau berbilang fasa.

i) Write **THREE (3)** characteristics of the chemical reaction in Figure 4 (c).

*Tuliskan **TIGA (3)** ciri-ciri bagi tindak balas kimia dalam Rajah 4 (c).*

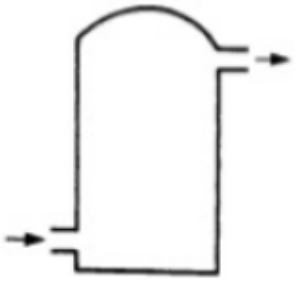

Figure 4(c) / *Rajah 4(c)*: Large reaction vessel for nitrogen oxidation

[6 marks]

[*6 markah*]

ii) Sketch **TWO (2)** multi-phase reactors for liquid-solid-gas phase with their names and processes.
*Lakarkan **DUA (2)** reaktor fasa berbilang untuk fasa cecair-pepejal-gas berserta nama dan prosesnya.*

[8 marks]
[*8 markah*]

CLO2

(d) Determine **TWO (2)** factors that increase the rate of reaction for this chemical reaction:
*Tentukan **DUA (2)** faktor yang boleh meningkatkan kadar tindak balas bagi tindak balas kimia ini:*

$$\mathbf{CaO\ (s) + H_2O\ (l) \rightarrow Ca\ (OH)_2\ (s)}$$

[4 marks]
[*4 markah*]

SOALAN TAMAT